that have been going on in the United States for the past few years over the efficacy of the emergency core cooling systems are now finding audience in Britain. The CEGB believes that the LWR is a safe reactor, although it is not clear how detailed an examination has been made of American literature on the subject.

The Nuclear Installations Inspectorate (NII), the body responsible for licensing nuclear plants, seems less certain. In an appearance before the Parliamentary Select Committee on Science and Technology, E. C. Williams, head of the inspectorate, said that it would take his department at least 2 years to examine the PWR thoroughly enough. He was not convinced, he said, that catastrophic failure of the pressure vessel was impossible, and he would have to carry out all the calculations again himself before he could be sure of it. If Williams were to demand extensive changes in the PWR—a prestressed concrete vessel instead of the steel vessel, for example—the LWR's prospects would be seriously hurt. The additional cost of the redesign and the risk of mistakes would reduce the attraction of a system that could otherwise be bought almost off the shelf.

The critics of the LWR have been hampered by the lack of a convincing British design to put up against it. So far, the most persuasive case has been made for the Magnox system—a gas-cooled graphite-moderated reactor in which natural uranium is used; nine of these were built in the 1950's and 1960's at a total cost of about $1500 million. The Magnox reactors have given good service, marred only by corrosion of some unimportant components so that it has been necessary to downrate the stations by lowering gas temperatures. The problem could be avoided in a new Magnox at a cost of a few thousand dollars.

The major drawback of the Magnox reactors is their high capital cost. At a time of inflation, however, critics argue that that may be less important than the fact that the Magnox is a proven design which the CEGB is used to building. A Magnox reactor completed on time, they argue, could compete with an LWR which was nominally cheaper, but which took longer to build because of the newness of its technology.

The calculation depends on just how wide the price gap is between Magnox and LWR. Some figures suggest that it is not as wide as the CEGB suggests. Moreover, Magnox reactors require no expensive enrichment capacities and would thus be independent of the supply of enriched fuel which has already caused an argument in Europe and which some industry analysts see as a future problem.

However hard the LWR's critics try, though, they are not quite convincing that an LWR would not be a cheaper option than Magnox. At best, the difference for a 2400-megawatt station would be $24 million and it could quite easily be two or three times as great. A difference of this order could only be made up if the Magnox system could show a much higher availability and shorter building time than an LWR, or if it could be demonstrated that the safety aspects of the LWR simply do not come up to acceptable levels.

Safety is probably the crucial issue in the debate, and the only one in which the LWR's position is in any doubt. The decision probably rests on the CEGB's ability to convince the government and the NII that the LWR can be built without compromising safety standards.

If they can do this, and if the government has the courage to throw overboard nuclear research that has cost Britain around $1300 million (not including the construction costs of commercial stations), then Britain is likely to come into line with the rest of the world by ordering LWR's. The best the British nuclear community can hope for as a sop to its pride is that the CEGB will also place an order for a single high-temperature reactor, as a "demonstration plant."

But nobody is yet taking any bets on the outcome. Peter Walker, Secretary of State for Trade and Industry and also Chairman of the Nuclear Power Advisory Board, has said that a decision will be taken early next year. If he backs the CEGB, it is likely to prove one of the most contentious decisions in industrial policy ever made by a British government.

—NIGEL HAWKES

Mr. Hawkes is the science correspondent of the London Observer.

Helium Conservation Program: Casting It to the Winds

After 10 years of criticism by the Congress, 4 years of dispute within the Administration, and nearly 3 years of litigation in the courts, one of the country's oldest conservation programs has been canceled. It was a plan to put away for future generations vast quantities of helium—a unique natural resource that is being rapidly wasted. The helium conservation program, by which the government paid private companies to extract helium from natural gas and store it underground, ran into serious financial problems in 1969. A drive to eliminate the program, which apparently originated within the Office of Management and Budget (OMB) during the first Nixon Administration, now seems to have succeeded. Late last year, the government ceased stockpiling helium under conservation contracts, and two large extraction plants are now simply letting helium stream up into the sky at the rate of more than 1 billion cubic feet per year.

Critics of the government's action are concerned that the United States is wasting a unique substance for which there may be no real substitute in many applications. Helium may be irreplaceable in providing the low temperatures needed for practical applications of superconductivity, because liquid helium is colder than any other fluid. Helium is also chemically inert, nonflammable, and does not become radioactive. Helium is used as an undersea breathing gas, for industrial welding, and to provide the controlled atmosphere necessary for manufacturing solid-state electronic devices and for processing nuclear fuels. The largest use of helium at present is in the space program, as a

pressurizing and purging agent for liquid-fueled rockets.

The demand for helium for conventional uses is growing slowly, but a much greater demand for helium could arise from new technologies to produce and distribute energy. Without helium, the production of virtually infinite amounts of energy from thermonuclear fusion and the transmission of large amounts of electricity by superconducting power lines, and conversion of coal to electricity in magnetohydrodynamic plants are thought to be unlikely or impossible. New materials could possibly be found for superconductors without helium, but all practical systems now require it. Gas-cooled breeder reactors, alternatives to the current U.S. design for a breeder, would also require huge volumes of helium.

But these technologies are still embryonic, and they are not expected to become practical until the next century. Right now, helium is abundant and the helium conservation program is expensive. So the Administration has apparently taken the position that fiscal economy in the short run is more important than conservation of helium for the future, when the country may need it most.

Helium is found in the atmosphere, but it occurs mainly in natural gas. The concentration in most gas reservoirs is so low that recovery has never been economically justified, but several fields of natural gas in Kansas, Oklahoma, and Texas are extremely rich in helium. Because of their unusual geological characteristics, these fields may contain natural gas with as much as 2 percent helium, and together they comprise the world's largest known reserve. But like most other sources of natural gas in the United States, the fields near the Oklahoma Panhandle have been thoroughly developed by private companies and are being rapidly depleted. As far as the gas companies are concerned, helium is a harmless impurity, which escapes into the air with the products of combustion when natural gas is burned. As a result, the helium

Briefing

Weinberg Leaves Oak Ridge Lab

Alvin M. Weinberg, one of the nuclear establishment's preeminent visionaries, has retired as director of the Oak Ridge National Laboratory, a job he has held since 1955. Weinberg, who is 58, plans now to start a small think-tank for energy issues at Oak Ridge, Tennessee.

His departure from ORNL was disclosed in a brief announcement released on 18 December by the Union Carbide Corporation, which runs the facility under contract to the Atomic Energy Commission. The announcement offered no explanation for Weinberg's leaving, and he was not immediately available for comment.

In 18 years as ORNL's director, Weinberg led the laboratory out from under its military shroud and into a new role as a center for biological, environmental, and peaceful energy research. He himself emerged as an important conceptualizer of new reactor types, a commentator on science-government relations, and an enthusiastic—sometimes controversial—advocate of a nuclear powered future. In recent years, Weinberg is said to have chafed at AEC's tighter reins on the national laboratories and to have clashed on a number of issues with some members of the AEC and the Joint Committee on Atomic Energy in Congress. Among the sorest points reportedly has been the AEC's reluctance to fund the development of gas-cooled and molten-salt breeder reactors, as insurance against major problems that might crop up in the all-out effort to build a commercial liquid-metal fast breeder reactor. Weinberg has also questioned the adequacy of experimental evidence underlying official assurances of reactor safety, and nuclear critics have put his misgivings to good use.

Early last year, rumors circulated around Capitol Hill that Union Carbide, whose lucrative operating contract was coming up for renewal, had begun to view Weinberg as a liability and was trying to ease him out. Friends on the Joint Committee interceded, and Union Carbide apparently had second thoughts; last February, Weinberg took an extended leave of absence, reportedly on the understanding that he could resume the directorship if he wanted it. Indications are that he did not.

The new Institute of Energy Analysis promises to give Weinberg the chance to devote more time to the problems of "trans-science" as he calls them—issues such as nuclear safety that meld social and political decisions with scientific judgment. According to a prospectus prepared by Weinberg, the institute will function as a "super-think-tank" for systems analysis, serving as a rallying point for the work of more specialized groups and as an "honest broker" of advice to the government.

Plans contemplate a staff of about ten and initial support from the AEC. Officially the institute will be an arm of the Oak Ridge Associated Universities, a nonprofit organization of 42 schools in the South which are linked to the national laboratory.

The laboratory's new director as of 1 January is Herman Postma, a plasma physicist who, like Weinberg, has spent virtually his entire career at Oak Ridge. Postma has been director of the laboratory's thermonuclear division since 1967.—R.G.

EPA Severs Ties with Industry Research Group

In what can best be described as a friendly parting of the ways, the Environmental Protection Agency (EPA) has decided to cut its ties with the Coordinating Research Council–Air Pollution Research Advisory Committee, known as CRC-APRAC, an air pollution research organization funded mainly by the oil and auto industries. EPA's participation in the group has been criticized by Senator Edmund S. Muskie (D–Me.) and by some public interest groups as posing a conflict of interest for EPA, since the joint research is intended as input to federal pollution standards which it is EPA's job to set (*Science*, 24 August 1973).

In disclosing the decision, Senator Muskie praised EPA Administrator Russell E. Train. But officials at CRC-APRAC said the decision to sever ties had come to them as a "surprise" since they believe the CRC-EPA relationship to be exemplary among industry-government

will run out when the natural gas does, probably between 1985 and 1995.

The Department of the Interior set up the helium conservation program in 1961 after Congress had passed the 1960 Helium Act Amendments. Under the program, Interior signed 22-year contracts with private companies to extract the gas from the Hugoton and Panhandle natural gas fields at a fixed price. The companies simply separated the helium from natural gas as it flowed out of wells, then pumped the helium via pipeline to the Cliffside Field, a partially depleted natural gas cavity near Amarillo, Texas (see map). Because the Congress set an annual ceiling of $47.5 million for helium extraction and storage, only about half the helium from the Panhandle area was being recovered by the conservation program. Nevertheless, by 1972, 35 billion cubic feet of helium had been laid away—60 years' supply at the present rate of national consumption.

The government is also in the business of selling helium, and the income from helium sales was supposed to pay for the conservation program. At first, funds were borrowed from the Treasury to cover program costs, but within 35 years the program was supposed to pay for itself. Government sales declined sharply in the mid-1960's, however, as the space program was cut back and private companies entered the domestic helium market in competition with the government. Instead of paying its own way, it appeared in 1969 that the helium conservation program would eventually owe the Treasury $1.5 billion for loans and interest. Furthermore, many critics, including the General Accounting Office, pointed out that the contractors earned enormous profits. *Time* characterized the helium program in 1971 as "The Great Balloondoggle," and a writer for *The New Republic* observed that, in view of the overwhelming surplus, "Favoring helium conservation had the uncertain aura of stashing Confederate money." Practically all observers, except perhaps the contractors, agreed that the Inte-

Briefing

cooperative research. The group supervises about 30 technical studies in atmospheric chemistry, health effects of pollutants, and engineering problems at think-tanks and universities around the country. The operation has been supervised by a hierarchy of committees on which EPA representatives sit, but they are outnumbered by those from auto and truck companies, oil companies, and think-tanks. Industry has paid three-fourths of the bill; EPA has paid the balance.

Muskie and the public interest groups, such as the Nader offshoot, Public Interest Campaign, have said that aspects of the research sponsored by CRC-APRAC has been biased in favor of industry. In his letter announcing the decision, however, Train said past CRC-APRAC work was objective. But he said that "not only the fact of objectivity but the appearance of objectivity must be considered when it comes to evaluating continued EPA participation in this activity." The EPA would stop sitting on the committees and funding projects no later than 31 August 1974, Train said. Current plans include EPA's taking sole responsibility after that time for ongoing projects.

Muskie also released an internal EPA memorandum supporting his contention that industry spokesmen view CRC-APRAC projects as devices for hindering pollution regulations set by EPA. The memo related that a representative of Cummins Engineering Co.—one of the nation's two principal manufacturers of diesel engines—had told an EPA official last June that one CRC-APRAC project "was the most 'effective coup that the industry has pulled off on EPA' as it commits EPA to a long, complicated project which is bound to result in additional delays which could postpone instituting controls for heavy duty engines for many years."

—D.S.

Noncooperation with Russia: One Man's How-To

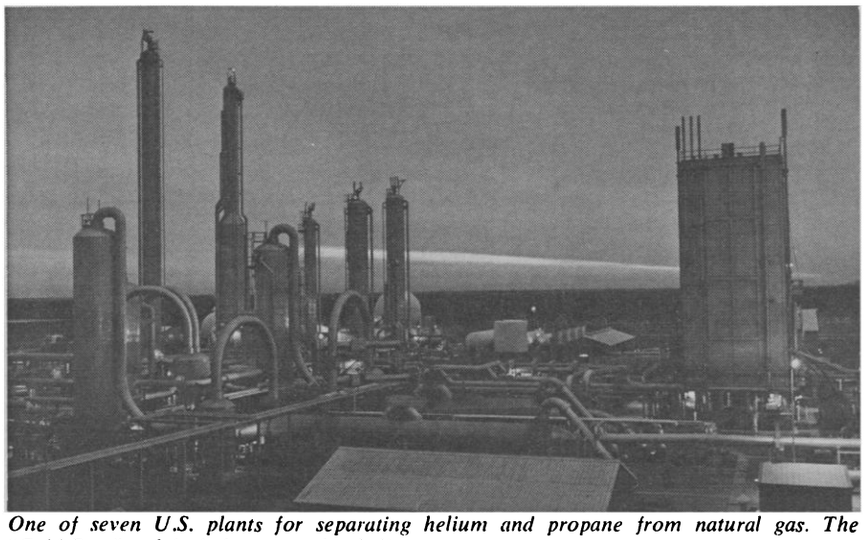
The recent disillusionment with détente and consequent strain on Soviet-American scientific ties has led to a lot of talk—but few known instances—of noncooperation with scientists in the Soviet Union. But Marc H. Richman, professor of engineering at Brown University, has devised what he thinks is a novel protest tactic for helping Russian scientists who have tried unsuccessfully to emigrate to Israel and for simultaneously maintaining contact with Russian colleagues.

Not long ago, Richman received a request from E. M. Nadgornyi of the Institute for Solid State Physics of the Soviet Academy of Sciences for some specialized information on computer simulation techniques, to which Richman had alluded in his technical publications. Richman, who has never been to the Soviet Union, says that generally he responds to such requests from Russian scientists with a friendly letter and the desired information.

However, this time, he replied to Nadgornyi saying that while he favored collaboration between scientists of "all countries . . . I cannot condone the official attitudes of the Soviet government in respect to such noted scientists as Professors [Alexander] Lerner, [Benjamin] Levich, and [Andrei D.] Sakharov." Therefore, Richman explained to Nadgornyi, he was sending the requested information to Alexander Lerner, a noted scientist who applied to emigrate from Russia in June of 1971, and who, like Nadgornyi, lives in Moscow. Nadgornyi, therefore, could pick up the information which includes, among other things, a number of computer programs, from Lerner. Richman says he sent letters and the information by registered mail since, in his experience, this kind usually gets through.

Activists in the cases of Jewish rights and civil liberties of Soviet citizens, asked about Richman's protest, replied that they viewed it as a useful technique. One scientist said that encouraging this kind of contact between Nadgornyi and Lerner could, in turn, ecourage solidarity among scientists there. Another scientist, who has been to Russia several times, praised the technique because it was "polite" to all concerned. As for Richman, he says he has reason to believe his letters have been received in Russia and that other scientists have been following his example, including some who say that they normally "tear up" such information requests from Russians.

—D.S.

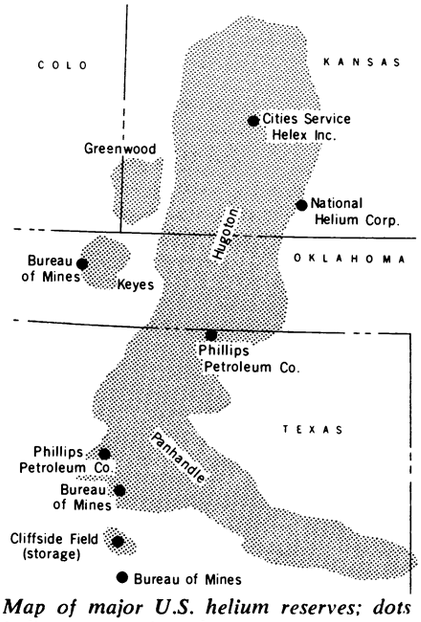


One of seven U.S. plants for separating helium and propane from natural gas. The "Cold Box," at left, is for extracting helium.

rior's program for conserving helium was no longer workable.

The Department of the Interior's Bureau of Mines had contracted with four companies—National Helium, Northern Helex, Cities Service Helex, and Phillips Petroleum—to supply raw helium for storage at a fixed price of about $12 per 1000 cubic feet. Each of the companies built a large multipurpose plant to extract propane, butane, and other salable impurities, as well as helium, from natural gas. At the same time, the Bureau of Mines set an artificially high price of $35 per 1000 cubic feet for purified helium produced by the government. When the helium conservation program began, the Bureau of Mines produced almost all helium sold in the United States, but private producers—some of whom were the companies participating in the conservation program—were soon able to undercut the government's price by $10 to $15 per 1000 cubic feet.

By 1970, the government's share of the helium market had shrunk to 40 percent, and the Department of the Interior was running far behind in payments to the helium contractors. The Interior Department attempted to increase its share of the market by requiring all federal contractors to buy only the government's helium, but the courts ruled that the President alone could issue such an order. Walter J. Hickel, then Secretary of the Interior, tried several times during 1970 to get such an order from the Nixon White House but did not succeed. As a last resort, the beleaguered Department of the Interior—many of whose officials apparently supported helium conservation to the bitter end—attempted to renegotiate the contracts at lower prices. At that point, one company, Northern Helex, filed a suit for breach of contract because the government had fallen so far behind in payments. After Hickel's departure from the Administration, Under Secretary of the Interior Fred J. Russell became acting secretary. Under the directions of OMB, sustained by the White House, Russell advised all companies on 26 January 1971 that the contracts would be terminated. But the helium conservation program survived three more years, as the contractors obtained injunctions against its cancellation.



Map of major U.S. helium reserves; dots indicate extraction plants.

The Department of the Interior had not drawn up an environmental impact statement before canceling the helium program, so the three companies still extracting helium—National Helium, Cities Service, and Phillips—were able to employ the environmentalists' favorite legal tool in order to protect their contracts. On 26 March 1971 the U.S. District Court in Kansas issued a preliminary injunction against termination of the contracts. The same court subsequently found that an environmental impact statement prepared by the Interior Department was incomplete, but the decision was overruled by the Denver Court of Appeals, and the injunction was dropped. On 12 November 1973, the Administration finally succeeded in canceling the helium conservation program.

The helium contractors have not decided whether to appeal this decision, but their actions suggest little hope that the program will be resurrected. National Helium, the largest plant, has closed its helium production facilities. Because of a different plant design, Northern Helex and Cities Service cannot stop producing helium without halting profitable propane and butane production, so they now release as much helium into the air as they used to store. Phillips is also producing as much helium as before, and is simply reinjecting it into natural gas after it is extracted.

Helium conservation has been supported by scientists and the small helium industry, but environmental groups have shown little interest in the issue. A report on physics by the National Academy of Sciences in 1972 strongly recommended continuation of the helium conservation program. An earlier academy report, *Resources and Man*, made similar recommendations. The companies that held helium conservation contracts organized a Helium Society, whose members were mostly scientists, to make the benefits of helium visible. The National Science Foundation is funding a study focusing specifically on the question of helium conservation, but the study, in which the Department of the Interior declined to participate, will not be completed until early 1974. Many of the scientists supporting helium conservation conduct research that cannot be done without helium.

The future effects of wasting helium may be enormous. Both the Bureau of Mines and the Stanford Research

Institute estimate that sometime between 1985 and 1992 helium demand will exceed the yearly supply. At that time, the United States will either have to find new supplies or start drawing on its reserves. The Bureau of Mines suggests that natural gas fields with a low helium content are the most likely new supplies, but many competent observers think that the reserves of natural gas now known—whether rich in helium or not—will be exhausted at about the same time. The Bureau of Mines predicts that new sources of natural gas containing helium will be found. In any case, it is possible that by the end of the century the United States will have to rely heavily—if not exclusively—on extracting helium from the atmosphere.

Recovery of helium from the air could have a staggering impact on the environment. Having canceled the helium conservation program, the government has, in effect, abandoned 20 billion cubic feet of helium. To recover that much helium from the air by liquefaction would require 2 years of the country's present total production of electricity. Thermal pollution would be produced by both the generating plants and the helium recovery plants. The Union Carbide Corporation estimates that the thermal pollution from producing 3.8 billion cubic feet of helium per year in the year 2000 would raise the temperature of the entire Mississippi River about 10°F, if it were used for once-through cooling.

Not only may future helium shortages force the country to resort to production methods that are extremely wasteful of energy, but higher costs of producing helium could make fusion power production and superconducting transmission cables less appealing economically, and thus their application might be delayed. Whatever the specific consequences, the government's policy will require future generations to expend a lot more energy to obtain a vital resource—helium—than ought to be necessary.

The final irony of the demise of the government's efforts to conserve helium is that the contracts binding the Department of the Interior are more stringently written than most government contracts. Upon termination, the contracts require payment to the companies for the undepreciated capital costs of the private helium plants. So, whether 20 billion cubic feet of helium is wasted or not, the Department of the Interior will probably end up paying at least half the cost of saving it.

—WILLIAM D. METZ

RESEARCH NEWS

Molecular Probes: A New Way to Study Gene Expression

Although the cells of a multicellular organism have identical genes (DNA sequences that code for proteins) no cell expresses all of its genes. The differences between skin and nerve cells, for example, are believed to result from the expression of different genes by the different cells. No detailed explanation of gene expression exists, but it is now possible to investigate this phenomenon by means of a molecular probe for specific messenger RNA (mRNA) copies of genes. This molecular probe has recently been used to study the expression of hemoglobin genes in developing red blood cells and to study the expression of genes that code for cellular responses to steroid hormones. Many researchers are optimistic that the probe will enable them to determine which cellular components are necessary for gene expression.

The molecular probe for specific mRNA's was developed independently in the laboratories of David Baltimore at the Massachusetts Institute of Technology in Cambridge, Sol Spiegelman at Columbia University in New York, and Philip Leder at the Molecular Genetics Laboratory of the National Institutes of Health in Bethesda, Maryland. It consists of a copy of DNA that is complementary to a specific mRNA and is radioactively labeled. The complementary DNA (cDNA) is transcribed from the mRNA with a reverse transcriptase, an enzyme that transcribes DNA from RNA. When cDNA is added to extracts of cells, it binds to its complementary mRNA. The cDNA that has bound to its complementary mRNA can then be separated by enzymatic degradation of the unbound cDNA. This assay is particularly simple, since the degraded cDNA is soluble in acid, whereas the cDNA-mRNA complex is insoluble in acid.

The development of a cDNA probe for a specific mRNA depends on the isolation of the specific mRNA from which the cDNA is transcribed. Specific mRNA's can as yet only be isolated from cells that produce a large quantity of a specific protein. In some cases, cells can be chemically stimulated to produce large amounts of a protein. For example, hen oviduct cells produce ovalbumin in response to estrogen. The ovalbumin composes 65 percent of all protein synthesized in these stimulated cells. If progesterone is administered after the estrogen, the cells respond to progesterone by producing large quantities of avidin. Bert O'Malley and his colleagues at Baylor College of Medicine, Houston, exploited this regulatory system to show that hen oviduct cells produce these responses to steroid hormones by controlling the transcription of mRNA.

Investigators have speculated that the synthesis of certain proteins could be regulated by substances that control either one of two processes: the transcription of DNA into mRNA or the translation of mRNA into protein. In eukaryotes (nucleated cells), these two processes take place at different times and in different places. It is possible to determine whether protein synthesis is regulated by transcriptional controls, since, if so, different cells should produce different mRNA's.

O'Malley and his associates could study transcriptional controls in hen oviduct cells because they could isolate ovalbumin and avidin mRNA's (by sucrose gradient centrifugation) and could thus transcribe cDNA probes for these mRNA's. The cDNA probes can be used to monitor the appearance of ovalbumin and avidin mRNA's in hormone-stimulated cells and the appearance of these mRNA's can be correlated with the appearance of ovalbumin and avidin. The cells, O'Malley found, re-